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THE
CHANNEL RAILWAY

SECOND EDITION

JAMES CHALMERS.



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THE CHANNEL RAILWAY

CONNECTING

ENGLAND AND FRANCE.

*Illustrated by Chart of Soundings, and Lithographed
Plans.*

BY JAMES CHALMERS,
INVENTOR OF THE "CHALMERS TARGET."

SECOND EDITION.



"We invite the competent authorities to examine his project."—*Times*.

"As an exposition of engineering skill it deserves high consideration."—*Liverpool Albion*.

"The plan of submerged tubes has met with most favour from engineers; it is, undoubtedly, the cheapest, and presents the fewest engineering difficulties. Of this system Mr. Chalmers is the ablest advocate."—*Mechanics' Magazine*.

"We cannot estimate the amount of either passenger or goods traffic that would flow by such a line. It would be limited, we believe, only by the mechanical capabilities of its trains."—*London Review*.

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PREFACE TO SECOND EDITION.

IF this were the proper time and place to refer to the many statesmen and others who have countenanced my project, and encouraged me to persevere, it would be found that some of the most distinguished men, in both countries, have patronised my proposal for a Channel Railway.

Objections, however, have been raised in certain quarters, founded chiefly on the fact that the project has not had the engineering experience of a Brunel, or a Stephenson. Still, many eminent engineers, both in France and England, are quite satisfied as to the practicability of the project; and eminent capitalists are equally confident that it would be a success commercially. But after all, my own engineering experience and observation have not been limited. With the exception of five years, my whole life, since boyhood, has been passed amidst mechanical and engineering pursuits. I lived at the end of "the great tubular bridge of Canada" during the time of its construction; had access at all times to the works; and, though unconnected with them, I had the advantage of a looker-on, who frequently sees more of the operations than those actively engaged.

About this time, I conceived the idea of a Submarine Tubular Railway at the Straits of Dover; and my friend and neighbour, Mr. John Dodsworth, of Montreal, who has had a life-long experience as a Railway engineer, not only aided me with the plans, but had such faith

in their practicability and importance, that he bore a share of the expense of bringing them before the public.

Since 1861, the question of our national defences has brought me in competition with many of our leading engineers. I have met Messrs. Hawkshaw, Fairbairn, Samuda, Scott Russell, Nasmyth, and others, before the guns at Shoeburyness ; where our respective theories of resistance were subjected to a test far more trying and practical than any competitive examination. The plans of my competitors, though backed by the resources of the Government, crumbled to pieces before the experimental guns, without leaving a trace of their existence in any of Her Majesty's ships, or advancing, save by their failure, the solution of the important question at issue. On the contrary, without any aid from Government, (which was denied me) the kindness and public spirit of Sir Morton Peto enabled me to produce a target, the trial of which has led to important changes in the construction of our iron-plated ships.

According to the *Times*, it was "the only target that fulfilled all the requirements of strength so needed and so long sought for ;" and the Secretary of the Admiralty stated in Parliament, the day following the trial, that "if this experiment is favourably reported on, it will lead to important alterations in our armour-plated ships." The official report was, that "No other target, designed for naval purposes, has resisted a similar weight of shot with so little injury." Accordingly, the alterations referred to have been made ; and Captain Noble, at the British Association, clearly showed that the recent alterations in armour were derived from the Chalmers Target. Pointing to the diagrams of the several classes of our iron-clads, he showed that the stringers of this target had

been embodied in one class; the second plate in another; and the stringers, second plate, and cushion in a third.

The chairman of the Iron-plate Committee stated, in his place in Parliament, "that one of the most essential and valuable principles of the Chalmers Target was embodied in the 'Bellerophon;'" and Sir John Pakington said, "He had no doubt that the invention was a most valuable one, and that it was of greater strength than the 'Warrior,' or any other target. He trusted that Mr. Chalmers would yet receive the reward to which he was so well entitled."

But the reward is still withheld. Though, with two gentlemen at the Board of Admiralty, having that high sense of public justice, honour, and consistency possessed by Sir John Pakington and Sir John Hay, this grievance cannot remain long without being inquired into and redressed. If other inventors have been troublesome to Government, I did not send in *my plans* uninvited; but was encouraged to spend my time, and £1,650 in money, by promises that my invention "would be carefully examined;" and that the Board of Admiralty "would cause my target to receive a fair trial." The improvements resulting from this trial, and the services thereby rendered to the country, have been frankly acknowledged by the Press, by scientific men before learned bodies, and by two of the present Board of Admiralty in the House of Commons. When the official acknowledgement is added to these, it cannot fail to have a beneficial influence in helping forward my project for a Channel Railway.

JAMES CHALMERS.

*Haverstock Hill,
London; December, 1866.*

THE CHANNEL RAILWAY.

CHAPTER I.

INTRODUCTION.

GLANCING over the Railway Map of Europe, the intelligent eye traces numerous lines tending to certain points, almost invariably to great cities. There is, however, one remarkable exception to this general rule: on the Continent, from North, East, and South, and in England from South, West, and North, lines are seen drawing together, stretching out their iron arms as if they would embrace, when, lo! they have stopped. There is no great city at either of their chosen termini: there is a valley between them; and such a valley as Railway Contractors would delight to make a road through; the land being cheap, the gradients easy, and the ground firm. But, it is part of the dominions of an old monarch, who refuses to grant the right-of-way, and seeks to impose upon others the restriction originally placed on himself—"Hitherto shalt thou come, but no further." Strong hopes, however, are now entertained that this valley may be crossed, and the converging lines united.

Three ways of effecting Railway communication between England and the Continent have been proposed—

Through the earth, by tunnelling under the bed of the sea; through the water, within submerged tubes; and through the air on a bridge.

Before introducing the present project, it may be well to notice briefly a few of the schemes that have already been before the public; to show how long the idea of roadway communication has existed; how earnestly the accomplishment of this great work is desired on both sides of the Channel; to illustrate the increasing interest that scientific and practical men are taking in the matter; and to enable the reader to compare or contrast the projects of others with the one now before him, in order to judge whether or not too much is claimed for this, in asserting that it is the most practicable method yet proposed for connecting the Railways of England and France. There have been before the world about a dozen projects for this purpose, including the present; three projectors, all French, proposed tunnelling under the Channel; seven, two French and five English, proposed submerged tubes; a Frenchman proposes an arched roadway, or tunnel, on the bottom; and an Englishman, a mammoth bridge.

The idea of tunnelling is much the oldest; a French engineer, Mathieu, sixty-six years ago, considered the work practicable, prepared elaborate plans, and laid them before Napoleon, then First Consul. They were some time exposed in the Luxembourg and other public galleries in Paris; but they have long been lost; and there is now, it appears, no account extant of the then proposed method of accomplishing the work. The project of M. De Gamond, also a tunnel, appeared in 1856, and may be reckoned, along with others that appeared about the same time, as fruit of the international exhibitions of 1851 and 1855. This project received more

than ordinary notice. A commission of eminent engineers, appointed to examine the plans, made a favourable report, and recommended an appropriation of £20,000, to make experimental examinations; and the Emperor is said to have looked upon it with favour; but it was finally rejected, on account of its interference with the navigation of the Straits. The plan, briefly, was to form in the Channel thirteen islands by carrying materials out to sea, dig down through them into *terra firma*, and tunnel east and west. To the advocates of the tunnel may now be added the name of Mr. Hawkshaw, who has been examining the shores and bottom of the Channel during the past year.

The submerged-tube projectors, with one or two exceptions, appear to have given the subject less study than the advocates of the tunnel. There is an easy, gentlemanly indifference about them—an *if*, a *might*, or a *perhaps*, cutting the Gordian knot of every difficulty that comes in their way: let one or two speak for themselves.

In an article, by Mr. Wylson, C.E., in the *Illustrated London News*, in which he gives a *résumé* of the plans of previous projectors, one gentleman says: "My plan is "simply to construct wrought-iron tunnels in separate "divisions; to sink them on the bed of the water; and "then to connect them. * * * It will be admitted that "to construct such a tunnel would be an easier matter than "to build iron vessels, as it would be the same shape "the whole length; then to sink it on the bed of the "water would be the work of only a few hours for each "division of 400 feet in length. Perhaps the part of the "work which will appear the most complicated will be "to connect the divisions under water. * * * The "operation will be attended with *no extraordinary diffi-*

“ *culty to those who can remain during half an hour in deep water.* * * * As regards that part of the tunnel which would be near the shore, it would be sunk under ground, and covered with stones fastened together, so as to render them immoveable. * * Then the railway will be formed in forming the tube; there will be no hills to cut through, valleys to fill up, or arches to build; in short, the sum total of the work is comprised in the tunnel itself.

“ Supposing the divisions to be 1,000 feet in length :—

“ In that case, only 104 divisions would be required to join the rails of the South-Eastern Railway with those of the Calais and Paris. Now, *supposing* each of these divisions would cost £40,000, the cost of the whole would be £4,160,000; and if we allow for the expense of *throwing* them in deep water, of connecting them, of building stations, &c., on a magnificent scale, it will, *I believe, be found*, that the sum of £8,000,000 sterling would be quite sufficient to complete this submarine railway.” The manner in which this gentleman speaks of *throwing* into deep water, iron tubes a thousand feet long, capable of containing a railway, is quite refreshing. This extract gives no idea of his method of keeping them on the bottom after he gets them there.

Another “project consists in crossing the English Channel, twenty-one miles in extent, by means of a tube made of strong plate iron, or cast iron, lined and prepared for that purpose; and which, placed at the bottom of the sea, should contain the two lines for the trains which would run within it. *The slope given to the submarine railway would admit of a motion sufficiently powerful to enable the carriages to cross the Channel without a steam-engine.* The greatest depth of the sea at the middle of

“ the Channel will admit of the construction of inclined
“ planes, by means of which the train would be enabled to
“ reach a point where a stationary engine, or atmospheric
“ pressure, *might* be employed in propelling the train to the
“ level of the land railways of France and England.”

The next does not place his tube on the bottom, but proposes “ to situate it at a uniform depth from the surface, by means of ties below (and *buoys* above, if necessary), at suitable intervals. The continuation of the “ tunnel into the shore on either coast *I should dispense with* ; and, in order that it should have a partial freedom “ of motion, it should terminate with solid ends before “ reaching the shores. To these points, chain piers should “ extend ; or, if strict economy (say, in the first instance), “ were aimed at in this item, the communication *might be by small steamers.*” As the tunnel or tube in question contains only a single line, the projector proposes “ *pushing* one way, and *pulling* the other ; ” or, he says, “ Electricity should, if at all practicable, be the motive “ power.” After proposing, as the principle of construction, something analogous to the cooper’s craft, he continues, “ when the tube was completed from end to end “ * * * favourable weather would be waited for, and the “ work of lowering would then be accomplished, nearly as “ follows :—The air-tight interior of each pontoon would “ be connected by an ample length of flexible pipe to an air- “ pump of adequate power, on board a vessel anchored at a “ distance corresponding to that intended for the mooring- “ weights. The two lines of vessels should be manned by “ steady men, each crew under a trustworthy leader. “ Athwart the vessels would be laid, from the shore, the “ wires of an electric telegraph, communicating with an “ apparatus on board of each ; so that, at a preconcerted “ signal, the abstraction of the air from the pontoons,

“ should be commenced simultaneously at a given time,
“ and carried on at a given rate. By this means, the pon-
“ toons, gradually deprived of their buoyancy, would yield
“ to the pressure of their burden—the buoyancy acquired
“ by which as it entered its future element would be over-
“ come by the weights with which, throughout its length,
“ it was loaded, and which would speedily sink it to its
“ prescribed depth. It would be when the tube reached
“ the water that the mooring-weights, having been prepa-
“ ratorily slung under the vessels above-mentioned, would,
“ at another signal by the electric telegraph, be *simul-*
“ *taneously let drop into the sea, and drag down their charge*
“ *along with them.*”

The proposer of the arched roadway, or tunnel on the bottom, will, with 40 subaqueous boats (of which he is the inventor), 1,500 sailors and navvies, 4,340,000 cubic yards of material, and £10,000,000, undertake to construct a tunnel, by means of which the Straits can be crossed in thirty-three minutes; and the mammoth bridge projector will make in the Channel 190 pedestals, 300 feet square at the bottom, consisting of rocks bolted and lashed together, gradually rising at an angle of 75° , till they form each an insular plain, 150 feet square, 40 feet above the level of the sea; on these, build towers 100 feet diameter, 260 feet high; and crown the whole with a tubular bridge 50 feet deep and 30 feet wide.

CHAPTER II.

THE PROJECT.*

IN introducing this project a second time to public notice, there is no desire to blink or under-estimate the difficulties of a work so extraordinary, new, and untried: on the contrary, the fulness of the details, and completeness of the provision made for every contingency, cannot fail to satisfy the careful reader that the great difficulties to be encountered have been fully studied and appreciated. One great difficulty is to get practical men to give the project an attention commensurate with the greatness of the subject; or even such as the humble but earnest labour bestowed upon it justly deserves. The fact that many crude and visionary schemes have been long before the public is against it. Some cursory readers may class this as another of the same stamp; still, there is an encouraging set-off in the changes that have taken place since these projects were published: new commercial treaties and greater freedom of intercourse, have increased both trade and travel in this direction; and the necessity for this work has now become so urgent; that, if it be found at all practicable within reasonable expenditure, its accomplishment cannot be long deferred. The simple greatness of the enterprise, and the immense interest con-

* Will be illustrated by drawings, covering 120 feet of space, in the Paris Exhibition.

of war. To the outer flanges of these frames, the timber casing would be attached by bolts; and the spaces between the timber casing and the tube proper filled with concrete. Finally, the interior would be lined with the most durable description of brick-work.

The timber casing, properly caulked, would be equal in strength and water-tightness to the planking of a frigate; the tube itself would be as tight and stronger than a steam-boiler or iron ship; and the concrete packing between the planking and the tube, would also be impermeable to water. Thus, not only is a double or treble precaution taken against leakage, but the iron would be protected, both without and within, from any injurious effects that might result from contact with sea-water; though, at the depth at which these tubes would be placed, such contact, even if possible, under the circumstances, would not be so injurious as if they were nearer the surface. "Count Marsigli divides sea water into "surface and deep-sea water; because, when he makes "salt from surface water (not more than six inches below "the upper strata), this salt will give a red colour to blue "paper; whereas the salt from deep-sea water will not "alter the colours at all. The blue paper can only change "its colour by the action of an acid. The reason why this "acid (iodine?) is found in surface and not in deep-sea "water is, it is derived from the air."* Hence, the bottoms of iron ships—when the interior skin of the iron is kept clean and well-painted—appear to suffer little or nothing from the action of the water on the exterior. There are many ships, twenty-five or thirty years old, the plates of which show scarcely any diminution in thickness. But, even if the iron of the tube were to suffer by oxidation

* Maury's "Physical Geography of the Ocean."

in forty or fifty years (a circumstance which, considering its position, is far from probable) the embankment, by this time silted up into a solid mass, the timber casing, the concrete, and interior lining, would of themselves insure the permanency of the Channel Railway.

The ventilator in mid-channel will be a circular mass of iron and stone, 100 feet in diameter, and 210 feet in height, 168 feet of which will be below the water-line. When finished, it will weigh about 100,000 tons, and displace 50,000 tons of water; it will be surrounded by, and embedded in, the embankment that covers the tubes, which at this point will be raised to a height of about eighty feet; and, as the storms that trouble the surface of the waters do not agitate them to a depth of more than thirty feet, this massive tower will be surrounded and sustained by a weighty body of water in a quiescent state, in addition to the embankment in which it is embedded. As to the action of the sea, the waves are only powerful when resisted: around the smooth iron sides of this round structure they will part and pass onwards: they will have four directions in which to expend their strength—upwards, downwards, and on either side; and the upward spray will be thrown back into the sea by the projecting curve with which the wall of the ventilator finishes above. The other ventilators would be ordinary air-shafts, near the ends of the shore embankments; which would be run out, breakwater fashion, about a mile from either shore, to a depth sufficient for navigation over the tubes.

CHAPTER III.

ILLUSTRATIONS.

FIG. 1. shows a section of the Channel, roadway, ventilator, and embankments, on a distorted scale; the longitudinal scale being one inch per mile, and the vertical a quarter of an inch per 100 feet. Such a scale gives an impression of greater unevenness than actually exists; there is no hollow on the proposed line (for which see Chart of Soundings) deeper than six feet below the general level; nor is there any gradient steeper than 1 in 120, about half the steepness of one on the North London Railway, between Shoreditch and Dalston junction. Indeed, so uniform is the bottom of the Channel at this point, that if the water were removed, rails might almost be laid on the natural surface of the ground.

Figs. 2., 3., and 4. are the Elevation, Section, and Plan of the deep-sea ventilator. The elevation is shown surmounted by two light towers eighty feet apart, and about forty in height. When the lights are in one, navigators will know that they are over the railway, and should be warned not to cast anchor. Not that any anchor could injure the tubes through the embankment, but the embankment itself would be scratched unnecessarily. The lower portion of the ventilator would consist of three wrought-iron cylinders—as shown in Plan, Fig. 4.—connected together by divisions all vertical, thus forming a series of cells for

the reception of concrete. The upper portion, where there is little pressure, would only have the outer cylinder, which could be strengthened with a temporary framing of timber until the inner wall of stonework was built.

The weight of the iron in this ventilator, independently of the short lengths of tubes attached to its sides, would be about 2,000 tons. These short tubes would have temporary water-tight bulk-heads at either end, and would be empty; and, as their weight is about equal to their displacement, they would not affect the submersion of the ventilator to which they are attached, though they would be made to render valuable assistance in placing it properly in its final position. The displacement of the inner cylinder, eighty feet in diameter, is equal to 1,500 tons for every ten feet in height. So, with a temporary deck below the line of the tubes—say five feet from the bottom—the ventilator would float in twenty feet of water; and, with 3,000 tons of ballast, it would draw forty feet, leaving 170 feet of its height out of water. With a second temporary deck, sixty feet from the bottom, and the same ballast, it would (with the space between the decks filled with water) draw between 90 and 100 feet. As it reached deeper water, the space between the decks could be allowed gradually to fill. When over its final position, the water would be allowed to flow into the space above the upper deck, until the ventilator rested upon the bottom of the Channel, when, if not correctly placed, pumping out, or the rising tide would again restore buoyancy—sufficient to enable it to be properly adjusted, by the arrangements for submerging the tubes hereinafter described.

When the ventilator is properly adjusted, a stiff clayey puddle will be deposited into each of the cells *c*., Fig. 4.,

calculated to form a bed of about three feet in thickness on the bottom; and, as the middle cylinder and cross-plates forming these cells do not reach within three feet of the bottom, this puddle will spread over the space—twelve feet in width—between the outer and inner cylinders, which alone reach the bed of the Channel. Upon this puddle would be deposited from above, such materials as would finally set or concrete into a solid mass, of 150 feet in height, which would press the said puddle into every crevice of the bottom, and effectually exclude all water from the interior of the inner cylinder, within which would be built the permanent mason-work *a*., shown in Figures 3 and 4.

Fig. 3 is a section of the ventilator and embankment, through one of the tubes, showing a length of 300 feet, *b d*, attached to the portion fixed to the ventilator. When the bottom is uneven where a joint is to be made, as at *d*, the inequality having been ascertained, a truss frame *e*, shown in cross-section on a larger scale in Fig. 5, is attached to the bottom of the tubes, which will prevent them from being drawn down too far; while the following tube *U*, will, as shown in Figs. 6 and 8, rest upon that previously submerged; and when they are joined together in the manner about to be described, they will be covered with rough materials, as shown in Fig. 7, which will fill up the inequalities of the bottom, and completely envelop the tubes. To secure a complete filling beneath the tubes, the triangular spaces *F*, are formed by plates of iron attached to the timber-casing by bolts, or such wood-screws as those used in France for securing the armour-plates to a ship of war. These spaces would be completely filled with concrete during construction, and the tubes would be connected together and kept in position laterally by the girder-braces *G*., formed of iron

plates, and placed about thirty feet apart. The details of the structure of the tubes are shown on a larger scale in Fig. 8—a longitudinal section, with the guiding and joining arrangements about to be referred to. The spaces W, between the timber casing and iron tube, would be packed with concrete.

The tubes would be constructed in lengths of 300 or 400 feet, and each length would be furnished with temporary bulk-heads at each end, as shown at H and I, Fig. 6. The displacement of a length of tubes would exceed the weight of materials by about 100 tons—the buoyancy to be overcome in submerging each length or section of 300 feet. If this buoyancy were found to be more than was necessary, it could be reduced by ballasting; for during this submerging operation they would be made to retain a portion of their buoyancy, and be drawn down by means of endless chains passing round pulleys or drums attached to massive anchor boxes on the bottom of the Channel: the chains would be made to indicate, by different colours or otherwise, the progress of descent. The anchors would be four in number, and so placed that their respective chains would be attached to the outside of each tube at the ends: the length of tubes would thus be secured at the four extreme corners. The chains will be connected with machinery on board vessels, which machinery, when set in motion, will have a uniform speed, causing the tubes to descend in a perfectly horizontal position; and, as the pulleys below, round which the chains pass, will be so arranged as to retain the portion of chain that passes through them—allowing no back-slip, the tubes in descending will gradually acquire the steadiness of the bottom of the Channel, getting rid of the unsteady motion of the surface. When a length of tubes has been safely submerged, a supplementary chain

or wire rope having, previous to submersion, been attached to—will disengage a key that secured the submerging chain to the tubes. The following operation will take place simultaneously in both tubes, though for convenience of illustration, the description is confined to one :—

In commencing to submerge a length of the tubes, a wire cable welded to the end of bolt, K, Fig. 8, is passed through the projecting portion of the timber, L, while the tube U, is on the surface of the water, the end of the bolt being previously fastened inside of the tube, T, already in its place and loaded down : a strain is kept on this cable—in nautical phrase, it is kept taut,—while tube U is descending; and, on its nearing its position, the bolt, K, guides the timber, L, till the projecting part rests on the timber, M, thus guiding the ends of the tubes together, when they are joined as shown in Fig. 6.

Tube T, Fig. 6, being in its place and loaded down, is empty inside of the bulk-head, H ; and tube U, having been brought into its place in the manner already described, it will be seen, by means of strong plate-glass in the bulk-head, H, aided by powerful reflectors, when the flanges, N, come together : * then valve, O, † is opened,

* The following evidence of the practicability of this arrangement is most gratifying; because, when the first edition of the Channel Railway was published, this was considered, by many, to be one of its most unfeasible features :—

“ M. Bazin, favourably known for his photographic researches, has contrived a very ingenious submarine photographic studio,” says the *Athenæum*, “ by which he is enabled to take photographs of sunken ships, rocks, &c. The chamber is provided with lens-shaped water-tight windows, and by means of the electric light the objects to be photographed are highly illuminated. M. Bazin has produced several clear and well-defined photographic pictures of objects, at the great depth of 300 feet.”

† A different description of valve, or a series of stopcocks, would be

allowing the water between the bulk-heads, H and I, to escape through tube, T; and the end pressure on tube, U, forces the timbers, P and M, together, with a power of about 500 lbs. per square inch of bearing surface; and, these timbers being provided with a ring of India rubber, R, Fig. 8, between them, a water-tight joint is thus effected. Workmen then pass through a man-hole into the division between the bulk-heads, H and I; and, by uniting the flanges, N, together with the plate, S, make a permanent joint. While this is being done, tube, U, is loaded down; and when sufficiently loaded, the bulk-head, H, is removed, and the operation repeated at the other end, which is furnished with similar arrangements, and so on till all are joined together. After the flanges, N, have been secured primarily by cramps, and before the plate, S, is finally riveted to the flanges, the space between them will be filled with some suitable packing, and the bolt, K, withdrawn. The nut will be removed, and the bolt forced out by a plug previously fitted to screw into the hole. But if, by any accident, the bolt should be withdrawn before the plug could be secured, the ball, V, Fig. 8, would roll into the bolt-hole, when the great pressure of the water would drive it into the opening like a bung, effectually stopping the hole.

The tubes are joined to the portions attached to the ventilator, in the same manner as they are joined to each other. The work of joining the tubes will commence at the deep sea ventilator, and proceed towards either shore on ascending gradients; thus, the water necessary to be withdrawn or admitted in submerging the tubes, will flow towards the deep-sea ventilator, where it will be

preferable to that which for convenience of illustration is shown in the diagram.

pumped out; and from this point, air can be forced or withdrawn through pipes to or from the end of the tube last submerged, in such quantities as may be required; which will create a free circulation, and render the work of joining the tubes an agreeable and healthy employment. Communication will be maintained by telegraph between the men employed at this work, and those at the surface of the water; and, as the rails can be laid as the work proceeds, ingress and egress to and from the bulk-heads would be attended with no inconvenience.

On a joining being completed, the anchor-boxes, about fifty tons weight each, would, with the submerging chains, be lifted by the rising tide, and moved to the proper position for the next joining.

In joining the sections of the tubes at a depth of 100 to 120 feet, we shall have an end pressure at, say, 50 lbs. per square inch, of 2,270 tons, forcing the tubes together; which, with a bearing 9 inches wide, gives 486 lbs. per square inch of bearing surface. Suppose we were to use $1\frac{1}{4}$ -inch round bolts, and have them 3 inches apart, we should have 388 in the circumference of the two tubes which, at 7,500 lbs. per bolt, gives a cohesive power of 2,910,000 lbs.; but, at the depth where the greatest number of joints will be made, we have a cohesive power of 5,083,200 lbs. equal to 673 bolts of $1\frac{1}{4}$ -inch iron. To enable the bulk-heads H. and I. to resist this enormous pressure, I propose to construct them with alternate layers of timber and iron (*a. b.* Fig. 8), like the compound backing of the Chalmers Target, which has been found to offer a better resistance to shot than any other arrangement.* Keeping in view this immense cohesive force,

* "No other target designed for Naval purposes has resisted a similar weight of shot with so little injury."—*Iron Plate Committee.*

which unites the newly submerged tubes to the portions previously placed, more firmly than the permanent joint subsequently made by rivetting the inner flanges together,—it is evident that there will be no necessity to delay till the permanent joint is completed before commencing the loading of the tubes; but the loading may commence as soon as the primary joining is satisfactory; and materials sufficient to load a length of tubes may be ready on the surface of the water, and deposited around and upon the tubes within twelve hours of the time when those in charge receive orders to proceed.

If, on passing into the space between the bulk-heads, after the water is drawn off, it be found that, though the timbers, M.P, Fig. 8, (the coffer-dam of these joining operations) have come together sufficiently fair to exclude the water of the sea, the inner flanges are not sufficiently so, to admit of being properly joined; then, by closing the valve and admitting water again between the bulk-heads, the cohesive power will be destroyed, and the defects in the joint having been duly noted, such exterior power can be applied through the submerging tackles, as will adjust the ends, and the final withdrawal of the water will enable the permanent joint to be proceeded with.

It is not likely, however, that such an operation would ever be necessary; for the two guiding bolts—one in each tube twenty-four feet apart—would bring the ends together by a similar principle, and with a nicety—considering the size—resembling the joinings of the pattern of the calico-printer, or the second colour of a chromolithograph. The end about to be joined could be allowed to lead a little in descending, which would keep the joint a trifle open at the bottom, and prevent any ruffling of the India-rubber ring R, as the ends came

together. When the other end of the tubes would be drawn to its bearings by the submerging tackle, the joining would generally be found sufficiently fair to admit of the opening of the valve, so as to bring on the hydrostatic pressure; and the U-shaped flanges N would admit of a perfectly secure joining being made, without that nicety of adjustment demanded by the ordinary L flanges.

I have dwelt thus long on the method for uniting the tubes together, for two reasons: First, because I am anxious to do justice to the principle, and to demonstrate the practicability of applying it. If I have failed in this, the fault does not lie in the principle, or even in the mechanical arrangements proposed for carrying it out, but in my inability to express my ideas with sufficient clearness. Second, because on this joining operation, depends the time that will be required to complete the whole work. The time requisite to make the several sections of the tubes will depend on the number of skilled workmen that can be obtained in both countries; and that, therefore, need not be taken into account, seeing that all the sections could be ready long before they would be wanted. But the time required to join one length to those already in position, is the criterion that will decide how long it will take to construct the Channel Railway. My anxiety to draw the reader's attention to this point arises from the fact, that, while it is possible to expedite all other parts of the work by employing powerful and perfect machinery, and increasing the number of hands, there is a limit beyond which this operation cannot be forced; and there are seasons during which, if not simply impossible, it would be at least injudicious and unsafe to attempt to perform it. From 160 to 200 days in the year, the Channel is suffi-

ciently smooth for submerging, joining, and loading the tubes. But, assuming that 120 days only will be fine enough for this purpose, and having two points of operations, we can attach a length of tubes to each for every four fine days; thus, the whole connection between the central ventilator and the shore embankments can be effected within two years, and the works between the ends of these and the shores go on, and be completed within the same time. As, however, a section of the tubes may be submerged or lowered at the rate of a foot per minute, or even faster; and, as it may be loaded down in twelve hours, sufficiently to keep it in position (the complete loading might be spread over several years); and as the works within can go on independently of fine weather above, it is quite possible to connect the whole in one fine season: thus, one year, or at most two, from the time of commencing the work of submerging, would see the Channel Railway *un fait accompli*.

The joining of the tubes under water, and from the inside, is the principal distinctive feature of my project: it is that which renders submarine tubular roadways in positions of great width and depth a possibility; the want of it nullified the plans of other projectors, compelling one to say, "the operation will be attended with no extraordinary difficulty to those who can remain during half-an-hour in deep water;" another, to adopt the proposition of building one tube twenty miles long, and sinking it whole; and the rest, to take shelter in a diving-bell, without showing how they would make it accomplish their object. The principle, then, which I use in joining the tubes—the mechanical law whence the force is derived to unite such immense masses in deep water, is old as Nature itself, and immutable as those

principles that work and govern the steam-engine, or the electric telegraph. I have not discovered this principle, I have only devised a method of applying it to new works by a simple contrivance, or invention, which will enable roads to be carried across wide and deep rivers, straits, and arms of the sea, heretofore thought impassable, and, at an expense proportionally less than the cheapest description of bridging. The Channell Railway, including four miles of tunnel-approaches, will cost £500,000 per mile, =£94 14s. per foot. The bridges that span the Thames in many instances cost five, and in some cases nearly ten times this amount. This extraordinary economy in expenditure, this almost absurd lowness of cost, is mainly due to the fact that the tubes, the principal feature of the work, require no costly stone-work, or expensive materials to support them, or any skilled labour to put such materials together: the embankment of broken stone that completely envelops the tubes has hardly to support any weight: the tendency of the tubes is upwards, pressing against the material above instead of that below; hence, the arrangement of the stones below into compact masonry is unnecessary, quantity only being required: they will fall around and beneath the tubes, filling up the inequalities of the bottom of the Channel, while the space between the tubes will retain sufficient to prevent their buoyancy from forcing the crown of the embankment.

It is not likely, with the example of the Atlantic Telegraph before us, that many would question the possibility of managing tackle, in the shallow waters of the Channel, sufficiently strong for such operations as those described in these pages. Nor would many, now-a-days, doubt the practicability of constructing iron

tubes capable of containing a railway; or, of making them strong enough to resist the pressure to which they would be subjected in the Straits of Dover. The guiding them correctly to their position under water, the joining them when there, and effectual arrangements for keeping them down, seem to have been wanting hitherto: it has been my study, not only to supply these, but to mature and complete a project by which this important work might be placed among the realities of the age. Besides the general features discussed in this pamphlet, I have considered means for inspecting the bottom of the Channel;* of taking correct measurements of distances therein, and soundings of points at which joinings would be made, provision for depositing the materials of loading and embankment exactly where required, and other minor details connected with various parts of the work, to treat which at length would require a much larger space, and many illustrations; and would carry me beyond the limits of a preliminary discussion. And why should I discuss details before the principle is accepted? It is still on trial at the bar of public opinion; and were I fond enough to hope that others would regard it with the interest and attention it has received from me, I would not be uneasy respecting the verdict.

* A chamber similar to M. Bazin's submarine photographic studio, but which would be furnished with mechanical appliances for turning and moving from place to place.

CHAPTER IV.

ESTIMATES.

It is not proposed in this chapter to give elaborated estimates, or the data on which they are founded; as, in any case, the figures must speak for themselves. In the first edition, it was argued, that such a work as the Channel Railway would be more likely, by giving an impetus to production, to lower prices than to raise them. This result has been accomplished, in a marked degree, in the case of plates for iron ships, especially the armour-plates of iron-clads. It is not, however, on account of any reduction in the price of iron since the first edition was published, that the estimate for the iron tubes now is £20 instead of £25 per ton, but on account of the greater simplicity of the tubes now proposed. The first proposal was for one tube thirty feet in diameter, capable of containing two lines of rails, and a brick lining of two feet in thickness; this tube was to have a central vertical division, attached by angle-bars, to the tube, and a ceiling forming flues connecting the central division with the tube. It is now proposed to have two tubes of sixteen feet diameter each, with but-joints, and without any complicated arrangements inside. The tube, in short, will be as simple in construction as the funnel of a large steamer. For similar reasons, the estimate for the iron work of the deep-sea ventilator, is reduced from

£35 to £30 per ton. In the first instance, it was proposed to make each of the cylinders, not only water-tight, but capable of sustaining a pressure of from 70 to 80 lbs. per square inch; as now proposed, one of them only will require to be water-tight, for the temporary purpose of floating the ventilator to its position, and it will not have to sustain a pressure of more than 9 lbs. per square inch. As to the price of labour, if the difference, since 1861, be not in favour of lower estimates; the present time is, at least, opportune, so far as the state of the iron trade is concerned, especially iron ship-building.

A section of a tube, fifty feet in circumference, and 400 feet in length, (equal to 20,000 super-feet), with $\frac{1}{4}$ -inch plates for the tube, half-inch iron for the girders and joint-plates, and a full allowance for rivets; would be 410 tons per length, or 820 tons for the double tube, which, at £20 per ton, would be £16,400 for each section of 400 feet. Of these there are 264 in twenty miles; but a few yards at each shore would be too shallow for sinking tubes, and belong more properly to the approaches. So, allowing for 260 lengths, or sections, the cost of the double tube would be:—

260 lengths at £16,400	£4,264,000
Connecting-girders G. and bottom-plates forming triangular cells F, 150 tons each length, or 39,000 tons, at £12	468,000
30 tons (each section) of $1\frac{1}{2}$ " bolts, at £12 10s.	97,500
8, 750,000 feet timber casing, fitted and caulked, at 1s. 9d. per foot	765,625
7,000,000 cubic feet concrete packing, at 8d.	233,333
13,104,000 ditto brick-lining, at 10d.	546,000
Submerging and joining 130 lengths at, say £5,000	650,000
Ditto ditto 130 ditto £3,000	390,000
Total cost of tubes	£7,414,458

Brought forward. £7,414,458

Deep-sea ventilator:—

2,100 tons iron-work, at £30	£63,000	
25,000 cubic yards stone-work, at £6	150,000	
30,000 ditto concrete, at £1	30,000	
Launching, placing, &c., say	100,000	
		348,000
2 air-shafts, in shore embankments		10,000
7,000,000 cubic yards broken stone, &c., at 5s.		1,750,000
3,000,000 ditto ditto shore embankments, at 3s.		450,000
Approaches and roadway, say		400,000
Preliminaries and contingencies		1,682,542
Total estimate		£12,000,000

In preparing the above, I have endeavoured to avoid the error of deceiving both my reader and myself with low estimates; an error into which some of those who have preceded me have fallen, in their anxiety to press their respective projects on public attention. I have, in all cases, exceeded the maximum rate when data were within my reach; because (as is too frequently the case in such matters) I have never looked upon my project as a hap-hazard, hit-or-miss, conception, but as a practicable method of accomplishing a great work. I am convinced that the realization of this work cannot be far distant, since the wants, the wishes, the peace, and the prosperity of two of the greatest nations on the earth demand it; and, as I might have some duty to perform in connection with its construction, I have endeavoured to make my project as perfect as possible; for on its obvious utility, and on the correctness of the estimates of cost and probable revenue, must depend its title to consideration.

I shall now select a few figures to show the difference between my estimates and those of projectors who have preceded me. I am aware of only two, besides myself, who have given detailed estimates.

Mr. Wylson's tube	-	£15,000,000
M. De Gamond's tunnel, at 25 francs per £		6,800,000

Mr. Wylson's tube was only to contain a single line, and to have no shore connections. His estimate for iron-work for tube and ventilator was £20 per ton, same as mine for the tube ; for the ventilator my estimate is £30 per ton. But, considering the complicated nature of the structure proposed, his tube * would be at least fifty per cent more costly than mine. M. De Gamond, in estimating the cost of material with which he proposed to form islands in the Channel, allows five francs per cubic metre of finished work ; and this material was to be of a compact nature, impermeable to water : my estimate for the stone to load the tubes and form the embankment is 5s. per cubic yard, being about 70 per cent. over the estimate of the French Engineer. This part of the work, according to my estimates, will cost £1,750,000 ; but at his prices, which he characterizes as the maximum, it would cost only about £1,000,000. With the same ratio of reduction applied to the whole estimate, my project could be carried out for about £7,000,000, instead of £12,000,000. He allows for contingencies 14,000,000 francs : I allow over 40,000,000.

Indeed, his estimates are so obviously inadequate that it is only necessary to quote his own figures, to show how unreliable they would be as a means of ascertaining

* "The principle of construction which I should propose would be analogous to that pursued in the cooper's craft ; the tube should be cylindrical, and consist of a system of staves and hoops. The staves should be about a foot thick, of wrought iron, hollow ; the side which formed an integral part of the interior of the tube, slightly concave ; the opposite, slightly convex ; the other two, planes radiating from the axis : midway in these planes, or joints, should be a hemi-cylindrical sinking, the two halves forming a whole for receiving a cylindrical iron core, or tongue, covered with some flexible material, which should also pervade the remainder of the joint, outside and inside the tongue."

the cost of such an undertaking. For depositing material in the sea (as already noticed) to form islands, through which he may penetrate into *terra firma*, he allows five francs per cubic metre, about 3s. 4d. per cubic yard. Sinking thirteen shafts, through this loose deposit in the open sea, from twenty-six to 192 feet deep, he estimates at 990,000 francs, about £3,000 each ; for the tunnel proper he allows for mining, pumping, ventilating, and removing and depositing the materials in the sea, nine francs per cubic metre, about 6s. per cubic yard. Tunnelling under water, especially such deep water as the Straits of Dover, is an undertaking involving much risk ; and where the distance is great, the risk is more than proportionally increased. The impossibility of ascertaining the exact state and nature of the ground through which the tunnel is to be driven, renders its completion a matter of great uncertainty : ninety per cent. of the work might present no serious difficulty, while the remaining portion might contain sufficient to render its abandonment more profitable than its prosecution. Examinations made by the French Government—at the request, I believe, of M. De Gamond himself—did not prove entirely satisfactory as regards the state of the ground for tunnelling operations. Both in these and subsequent examinations, indications have been discovered near the French Coast, of the strata of the bottom of the Channel being in a disturbed state ; arising, probably, from earthquakes at some comparatively recent period. Pockets and crevices filled with loose sand have been discovered, which, if they extend to any great depth, would render tunnelling, if not an impossibility, at least too uncertain an operation to warrant so great an expenditure. At the deepest point at which a tunnel would be driven, the head of water would give a pressure of 110 lbs per square inch ; and

if, at this point, a pick or drill should penetrate a crevice connecting with the waters above, the result might be the ruin of the entire undertaking. An accident of this nature, a few years ago, in the Lake district, not only flooded a valuable mine; but the jet of water passed through the body of the unfortunate miner, as if it had been an iron rod. The difficulties that may obstruct tunnelling operations, being unseen, can never be ascertained; and estimates founded on driving tunnels through chalk above the level of the sea can never be relied on. I know of only one instance of tunnelling on a large scale under water—the Thames Tunnel; and, though it may be unfair to take this most expensive work as a criterion for a similar work at the Straits of Dover, I nevertheless think it a safer one than the sanguine estimates of an engineer anxious to draw attention to his project. The great depth to which he must descend, in order to leave sufficient thickness between the arch of the tunnel and the bottom of the Channel, renders long-tunnelled approaches on either shore, necessary to insure suitable gradients for reaching the level of the adjacent country; hence M. De Gamond's tunnel is thirty miles and 333 yards in length; now, thirty miles, at the same cost per mile as the Thames Tunnel (£1,811,292) would cost £54,338,760. If no serious difficulties were encountered, it might possibly be done for less; but in a work of such an uncertain nature, no estimates, however ample, could be relied on; nor would the guarantee of any contractors, however wealthy, secure shareholders against further calls, to which the wisest could not set a limit. The Channel Railway, on the contrary, may, according to my project, form several separate contracts; the ventilator, tubes, embankments, tunnel-approaches, or portions of each, could be placed in the hands of men perfectly responsible; thus, not only insuring the com-

the cost of such an undertaking. For depositing material in the sea (as already noticed) to form islands, through which he may penetrate into *terra firma*, he allows five francs per cubic metre, about 3s. 4d. per cubic yard. Sinking thirteen shafts, through this loose deposit in the open sea, from twenty-six to 192 feet deep, he estimates at 990,000 francs, about £3,000 each ; for the tunnel proper he allows for mining, pumping, ventilating, and removing and depositing the materials in the sea, nine francs per cubic metre, about 6s. per cubic yard. Tunnelling under water, especially such deep water as the Straits of Dover, is an undertaking involving much risk ; and where the distance is great, the risk is more than proportionally increased. The impossibility of ascertaining the exact state and nature of the ground through which the tunnel is to be driven, renders its completion a matter of great uncertainty : ninety per cent. of the work might present no serious difficulty, while the remaining portion might contain sufficient to render its abandonment more profitable than its prosecution. Examinations made by the French Government—at the request, I believe, of M. De Gamond himself—did not prove entirely satisfactory as regards the state of the ground for tunnelling operations. Both in these and subsequent examinations, indications have been discovered near the French Coast, of the strata of the bottom of the Channel being in a disturbed state ; arising, probably, from earthquakes at some comparatively recent period. Pockets and crevices filled with loose sand have been discovered, which, if they extend to any great depth, would render tunnelling, if not an impossibility, at least too uncertain an operation to warrant so great an expenditure. At the deepest point at which a tunnel would be driven, the head of water would give a pressure of 110 lbs per square inch ; and

if, at this point, a pick or drill should penetrate a crevice connecting with the waters above, the result might be the ruin of the entire undertaking. An accident of this nature, a few years ago, in the Lake district, not only flooded a valuable mine; but the jet of water passed through the body of the unfortunate miner, as if it had been an iron rod. The difficulties that may obstruct tunnelling operations, being unseen, can never be ascertained; and estimates founded on driving tunnels through chalk above the level of the sea can never be relied on. I know of only one instance of tunnelling on a large scale under water—the Thames Tunnel; and, though it may be unfair to take this most expensive work as a criterion for a similar work at the Straits of Dover, I nevertheless think it a safer one than the sanguine estimates of an engineer anxious to draw attention to his project. The great depth to which he must descend, in order to leave sufficient thickness between the arch of the tunnel and the bottom of the Channel, renders long-tunnelled approaches on either shore, necessary to insure suitable gradients for reaching the level of the adjacent country; hence M. De Gamond's tunnel is thirty miles and 333 yards in length; now, thirty miles, at the same cost per mile as the Thames Tunnel (£1,811,292) would cost £54,338,760. If no serious difficulties were encountered, it might possibly be done for less; but in a work of such an uncertain nature, no estimates, however ample, could be relied on; nor would the guarantee of any contractors, however wealthy, secure shareholders against further calls, to which the wisest could not set a limit. The Channel Railway, on the contrary, may, according to my project, form several separate contracts; the ventilator, tubes, embankments, tunnel-approaches, or portions of each, could be placed in the hands of men perfectly responsible; thus, not only insuring the com-

pletion of the entire work, but fixing the ultimate cost before a shilling is expended. There is no desire to ignore the fact that difficulties beset the tube as well as the tunnel; but, if not above water, they are at least above ground, and can be estimated, grappled with, and overcome.

With the prices and data obtained from iron manufacturers, engineers, and contractors, I gave in the first edition a Minimum Estimate for connecting the Railways of England and France by a continuous double line, according to my project, which amounted to £8,000,000. A single line would cost about three-fourths of the respective estimates; thus, the maximum estimate for a single line would be £9,000,000, and the minimum £6,000,000. Though these minimum figures are founded on data at least as reliable as any used by other projectors, I do not put them forward as the probable cost of this work; but, for the purpose of enabling the reader to compare them with the estimates of others, I adhere to my first or maximum estimate as the safest. In endeavouring to avoid errors in this respect, into which, as it appears to me, others have fallen, I may have verged on the opposite extreme, by placing my figures too high: however, I prefer, for reasons already given, to come before the public with estimates fully capable of completing the work, rather than bring forward such as might be considered doubtful.

I cannot pretend to speak with the same certainty respecting the following estimates of probable revenue, there being no reliable data on this subject available; and though I feel confident they are within what may reasonably be expected, I frankly admit that they are founded chiefly on observations made while trading and travelling between England and France. I published these

figures in a brief prospectus of this project five years ago; and I see no reason to alter them now, unless to increase them. After I adopted them, I became acquainted with the work of M. De Gamond; and, on comparing figures, found a wonderful coincidence in the items of freight and passengers—

his being	-	-	-	-	-	£1,041,666	13	4
and mine	-	-	-	-	-	1,049,375	0	0

He seems to have overlooked the mails, as a source of revenue: his figures were compiled in 1856, and based on the actual business then done between England and the Continent; and, as he could not have foreseen the impetus that has since been given to traffic between England and France by the recent Treaty of Commerce, and by the change in the passport system, his figures are more sanguine than mine—compiled in 1861, after these important changes had actually taken place.

Estimate of Probable Revenue :—

2,500 tons freight daily, or 912,500 per annum,			
at 12s. 6d.	-	-	£570,312 10 0
1,500 passengers daily each way, or			
1,095,000 per annum, at 8s. 9d.			479,062 10 0
Mails, express-freight, coin and bul-			
lion, extra baggage, &c., say,			250,645 0 0
Total annual revenue	-	-	£1,300,000 0 0

These figures may appear too high to those who have overlooked the affinity between improved means of transit, and the increase of traffic resulting therefrom. In the infancy of railway enterprise, the anticipated traffic on a given line was based upon the business done by the stage-coaches and waggons of the day. I will not insult

the understanding of my readers by comparing the anticipated, with the actual railway traffic; but I may take the liberty of reminding them that our experience in that case did not prevent our falling into a similar error in the case of ocean steamers; and, though fleet after fleet of these vessels have taken their places on the ocean, each creating for itself a trade where none such existed before—I have found this the most difficult point to carry in discussing, with those interested, the subject of railway communication between England and the Continent. I am frequently told “there will not be sufficient trade to make it pay;” and I am referred to STATISTICS; as if, like the laws of the Medes and the Persians, *they* were unalterable—incapable either of augmentation or change of ratio—no matter what may be the increased facilities of intercommunication. Sometimes, I am referred to the Thames Tunnel as a test whereby to establish the probable commercial value of the work in question. I am asked, “If the Thames Tunnel, a quarter of a mile in length, connecting two populous districts of a great city at a place where any other roadway is impracticable, would not pay, how can you expect one twenty miles long to pay, where there is a scanty population at either end?” I answer, if the Channel Railway be so constructed that descent into it will, like the Thames Tunnel, be through a well-staircase, so situated that travellers will have to employ a guide to show them the entrance; and if, instead of a railway, there be no better travelling accommodation than a footpath, I readily grant that it will not pay; but if, on the contrary, it be made accessible by easy gradients, and capable of accommodating the railway trade of England and the Continent, so that traffic can be maintained between London and Paris, and other English and Continental cities, without change of

carriages or locomotives—if, instead of employing *three* vehicles, as at present, *one* only be required; we have but to glance at the effect which increased facilities have already had upon traffic in this direction, to be convinced that this will be one of the best paying works undertaken since the era of Railways began. Between 1820 and 1830, in the good old times of sailing packets, the number of travellers between England and the Continent did not exceed 80,000 per annum: the establishing of a regular steam-boat service raised the number in twelve years to 350,000; and, since the introduction of railways, it has risen to upwards of a million; this great increase is not to be attributed to the increase of the populations, but mainly to these improvements; and the effects that would result from the completion of this work, would be even greater than were produced by those two important revolutions in locomotion, which respectively raised the figures from 80,000 to 350,000, and from the latter to upwards of a million.

Travel, at present, is checked in this direction by the dread of sea-sickness: when this becomes, as far as the Channel is concerned, a thing of the past, the fetters that have hitherto confined thousands will be broken. Few are willing to admit, even in jest, the simple horror they entertain of this painful malady. A writer, with much truth and some extravagance, says, “The term ‘suffering’ does not in the least express the mental and bodily agony of my position on shipboard. * * * I am rendered intellectually an idiot, and physically a helpless log.” There are thousands, both in England and on the Continent, who will never acknowledge it; but who are nevertheless constrained by the fear of sea-sickness to make the Channel the eastern or western boundary of their travels. It is contended that the passenger traffic

is greatest in the summer months, when the sea is generally calm; but this is precisely the reason why the traffic is chiefly limited to the summer. Though the attractions of Paris are equally great in winter, they are not sufficient to induce many to brave the horrors of a passage over the sparkling waves. Again, it is argued, many will not travel under the sea; but neither would they travel under the land, until railway tunnels compelled them. Old ladies going to Bath have been known to make express stipulations that they were not to go through the tunnel.

"It may sound very dreadful in some ears to talk of passing through a "dark hole filled with mephitic vapours;" but put it to a poor sufferer while being tossed over the "sparkling waves," whether he so admires their beauties that he would rather prolong his enjoyment for a couple of hours, than be snugly seated in a comfortable carriage passing over the same space in thirty minutes, and what would be the reply? All sane people will readily imagine the answer. Besides, the darkness and mephitic vapours only exist in the fancy of the timid. Locomotive engines are now constructed to consume, not only their own smoke, but their own steam; and the tube would be both lighted and ventilated. Why, the very tube itself would be an attraction. Thousands would come from all parts of the globe merely to have the gratification of seeing and passing through so great, so wonderful a work."*

In order to form some idea of the obstruction which the Channel causes to railway traffic, let us suppose a mound or wall, obstructing, and dividing into two separate sections, all the railways connecting London with Manchester, Liverpool, and the North; and that

* Mr. Cook, in the *Mechanics' Magazine*.

all trains by day or by night, stopped at this wall, and changed their passengers and freight into other carriages ; that several valuable hours were thus miserably wasted, during which, passengers dreaded, suffered from, or witnessed upon others, the effects of a terrible malady ; that it cost the companies half the revenue derived from freight to transfer their goods traffic across this wall ; that, in short, they knew and felt that this obstruction "robbed them of half their gains." Under such circumstances, how long would this wall endure ? Would £12,000,000 be grudged to remove it—to effect an improvement that should add twenty-five, yea, fifty per cent. to the value of a hundred millions of railway property ? The Channel is such an obstruction ; cramping a traffic, which, untrammelled, would surpass that between London, and Manchester, Liverpool, and the North. This obstruction, I have shown, can be removed for £12,000,000.

The influence which the Channel Railway would have on the increase of passengers, however great that increase might be, would be eclipsed by the revolution it would create in goods traffic. In the first edition, I promised, at some future period, to take a statistical and more comprehensive view of this subject ; but the facts are now so generally admitted as to render any lengthened argument unnecessary. "We cannot estimate the amount of either passenger or goods traffic that would flow by such a line. It would be limited, only, by the mechanical capabilities of its trains." With the following observations by Mr. Cook of Whitehaven, I commend this question to those interested—convinced, that, if they take it up heartily, its importance will secure a careful investigation :—

"As to the commercial value of the undertaking, no

one who knows anything of the Continent and its productions, and can appreciate the facilities for a highly remunerative traffic, which the Channel Railway would open out, can doubt of its success as a paying speculation, if no more than twelve millions be expended in its construction. The Channel Railway, for its peculiar traffic, could have no competitor. Having been entrusted for several years with the active part of the management of the South Eastern Railway's Continental business, I am able to form some idea of the impetus which would be given to foreign travel and trade on both sides of the Channel, were this communication made ; but I believe the most sanguine estimates would be as far exceeded in this case as they were in the case of the first railways. The traffic, too, would be of the best paying description ; not minerals at $\frac{1}{2}$ d. per ton per mile, but first-class passenger traffic and light valuable merchandize, mails, bullion, parcels, &c. ; and this, not to and from France alone, but to and from the most distant parts of Europe. The new Commercial Treaty with France has already more than doubled our exports.* What would they be, were this Railway completed, and that Treaty changed to absolute free exchange of products, which would certainly follow ? ”

EXPENSES OF MAINTENANCE.

Before noticing these expenses, I propose that the work be looked upon more as a bridge than a railway—the company keeping no rolling stock, but simply charging a toll on the traffic. The anticipated expenditure of coal contemplates the possible necessity for artificial ventilation ; and the large item for “ Repairs, &c,” is intended to cover an annual expenditure of

* February, 1862.

£50,000 on the embankments, until that which covers the tubes shall reach 10,000,000 cubic yards, and the shore embankments 2,000,000 each ; this, at 200,000 yards a year, would be accomplished in twenty years.

Management, per annum, say	-	-	-	£10,000
10 tons of coal, per diem, at 20s.	-	-	-	3,650
60 men, at 5s. per diem	-	-	-	5,675
Wear and tear of engines and machinery	-	-	-	3,000
Repairs, &c.,	-	-	-	60,000
Contingencies	-	-	-	2,675
Total	-	-	-	£85,000

Thus, for an outlay of £12,000,000,			
we have an annual revenue of	-	-	£1,300,000*
Subject to an annual expenditure of	-	-	85,000
Leaving a nett revenue of	-	-	£1,215,000

being upwards of ten per cent. on the capital. I do not suppose that this would be realized during the first three or four years; though I have no doubt that a revenue sufficient to pay an average of five per cent. would be forthcoming even for these years. With the exception of M. De Gamond, the other projectors, as far as I can learn, have not given estimates of revenue and expenditure, apparently taking it for granted that the commercial value of the work is sufficiently obvious. This engineer's project contemplated connecting with the existing railways at Boulogne, Calais, and Dover, receiving and handing over passengers and freight at these points. His tariff was—Passengers, twelve francs each,

* "Mr. Chalmers, we think, places his estimate of a total annual revenue of £1,300,000 far too low."—*London Review*.

and ordinary freight twelve; express do. eighty, and extra baggage 100 francs per ton. His interesting calculations embrace a variety of subjects; among others, some illustrating the capabilities of his tunnel to accommodate the growing traffic it would create. But this traffic would eventually overtax the capabilities of even a double line, and demand at no distant date still greater accommodation.

CHAPTER V.

ADVANTAGES.

THE lion's share of the material benefits which the Channel Railway would confer, would fall, in the first instance, to existing railway companies, whose lines terminate at the Straits. If we estimate the value of the lines between London and Paris at £60,000,000, and suppose that their value would be increased twenty-five per cent. by the completion of this work, their capital would thus be improved to an extent exceeding the total cost of the undertaking. Nor would improvement in the value of railway property be limited to lines between Paris and London : distance will lessen but not destroy its beneficial influence in this respect ; for other lines connecting with these railways, though located beyond London and Paris, would participate in the general increase of traffic ; and those terminating at Liverpool and Marseilles, Manchester and Strasbourg, would experience an improvement, second only to the railways having a direct connection. The immense increase of goods traffic which would accompany the opening of this work, would alone accomplish the above results ; and the tolls of the Channel Railway could be paid from such rates as are now paid for ferryage, without encroaching on those of the connecting railways. Thousands of packages sufficiently valuable to pay railway

freights, that are now shipped from Continental to British ports direct, and all British exports to France, Central and Northern Europe (except cheap and bulky goods), would pass over the Channel Railway, contributing to the general railway traffic of England and the Continent. The saving in interest on the value of merchandise, coin, and bullion, for the difference in time between delivery by this and other routes, and the saving in sea-insurance, would alone be sufficient to secure all the light and valuable, and best paying traffic.

The saving of time, and immunity from the mental, moral, and physical wear and tear occasioned by a rough Channel passage, are not the least important of the blessings which the Channel Railway would confer on its patrons. The time saved cannot be reckoned by the mere crossing of the Channel ; when the trip to Paris, like that to Manchester, is performed in five hours, these hours can be selected from a portion of the twenty-four that will not interfere with the business of the day. True, one can save a day at present by forfeiting his rest, travelling at night, subjecting himself to sundry uncomfortable changes at each side of the Channel, and the risk of something worse in the middle : this saving, however, is not due to the means of conveyance, but to the self-denial and exertions of the man, who may at any time make an extra day, without going to Paris, by working all night instead of going to bed.

In the first edition, I gave some statistics, in which I endeavoured to show, that the increase in the value of Railway property, the saving of interest on merchandise, coin, and bullion, and the saving in sea-insurance, and of the time and expenses of passengers—in short, that the advantages to the public which this work would confer, would be about £2,000,000 per annum, independent of

the revenue derived by the Company from tolls. For these sanguine (?) estimates, I was properly rated by certain would-be authorities. "Nothing so extravagant," they said, "had appeared, even in the worst days of the Railway mania." On another occasion, I referred to the Metropolitan Railways, not only as evidence of the wisdom of connecting separated lines; but as encouraging proofs of successful engineering; and expressed the opinion that "they would doubtless be self-sustaining." My critics, however, "dissented entirely" from this; saying, "Our opinion as to the possible future remunerative character to the promoters of our Metropolitan lines is, that they will never pay one per cent., if so much, on the capital, above their working expenses!" The premium which the Metropolitan Railway stock commands now, is sufficient reply to an opinion which appears to have been lightly considered, and lightly given. I was not mistaken, in 1861, in my opinion of the commercial success of the Metropolitan Railway; nor, after five years' more experience, do I think £2,000,000 too high a figure at which to estimate the collateral advantages likely to accrue from the connections of our Railways with those of the Continent.* If such be a correct estimate of the DIRECT ADVANTAGES which the completion of the Channel Railway will

* "It is a curious coincidence that the writer of the Emertonian Prize Essay on the advantages of a close alliance between France and England, knowing nothing of Mr. Chalmers's proposal, estimates the annual saving to this country alone from such an alliance, at exactly twelve millions; so that, in one year the whole cost of the Channel Railway might be recovered by a mere mutual undertaking of good faith; but the Railway itself would form a material bond of amity, such as no paper guarantee could ever secure."—Mr. Cook, in the *Mechanics' Magazine*.

secure to the communities immediately concerned ; who can estimate the value of the INDIRECT—the impetus given to commerce, and through commerce to manufactures, and through both to every interest affecting the weal of two of the greatest nations on the earth ? If, then, we shrink from estimating such material concerns as properly come within the province of figures, what shall we say of its influence on religion, science, literature, civilization, and the peace and happiness of the human race.

CHAPTER VI.

THE CAPITAL.

THE Capital—how can it be raised? It is too great a work for any of the Railway Companies directly interested; perhaps too great for all these companies combined; but will any one say, that twelve millions cannot be raised in France and England; especially when the investment not only gives promise of a large direct return, but offers, besides, immense collateral advantages to both nations? If a strong company were formed, comprising some of the leading capitalists of the two countries, especially those interested in railways directly or indirectly connected, both Governments would doubtless countenance the undertaking. England and France could not do less to effect this most desirable communication, than England and America did for the Atlantic Telegraph. Were such a company to obtain a charter, granting the right of exclusive railway communication between England and France for a term of years, with a promise of aid in men and steam-ships in forwarding the work; and, perhaps, a guarantee of a minimum dividend on a certain capital for a limited period—then the question will not be who will subscribe?—but who will get the stock?

Influential names are accounted, nay, really are, indispensable in promoting undertakings such as this; but, while duly appreciating the influence and opinions of those who have earned a title to respect among their fellow-men, I hope all who feel an interest in this subject will endeavour to study and examine it for themselves

Though I have been encouraged by the countenance and advice of several of the leading men of both countries, I seek not on that account the good opinion of the public ; nor have I asked permission to shelter my project behind the respect which prominent and well-known names could not fail to inspire. Judged by its intrinsic merits, I am hopeful that the Channel Railway will soon count among its friends a sufficient number of great names to insure it a place among the wondrous achievements of modern times.

Who should encourage the Channel Railway ? The Queen of England. The lives of good sovereigns are grand chapters in the histories of monarchical nations ; true, England's present chapter is already bright, beyond historic precedent ; still, this enterprise completed in Her day, would shine among the works that grace Victoria's reign, like the Koh-i-Noor among the crown jewels.

Who should encourage the Channel Railway ? The Emperor of the French. He who planted amidst a warlike people an empire of peace—who is to-day devoting to the maintenance of order, to great and useful improvements, such power and energies as are too often devoted to bloody and destructive wars.

The Governments and Legislatures of both lands should encourage the Channel Railway. If enlightened statesmanship and wisdom actuated them in lately removing certain restrictions that hampered trade, they will not fail to remove another more annoying than customs' and tariff regulations ; and which has not even the merit of adding a penny to the exchequer of either country. Though these regulations require an inspection of imports, this is generally done where it best suits the importer ; but the Channel regulations are not so considerate ; goods are peremptorily stopped there, and not a few packages only, but all, subjected to sundry ex-

pensive handlings and delays. This serious inconvenience of changing from rail to steamboat, from steamboat to rail, tumbling, rolling, and damaging packages, will increase with increasing traffic to a jam—a nuisance; deranging the movements of trains, and sowing the seeds of future railway accidents—in short, it is the only serious impediment to the blessings expected from recent legislation.

The Channel Railway will be useful in peace; in war it would be harmless. Fears have been entertained that it might become an instrument of invasion; but both ends could be furnished with sluices, or valves, the opening of any of which would immediately inundate the roadway; effectually preventing invasion; and, after peace was restored, a few days would suffice to restore the communication. The friends of peace, therefore, should encourage the Channel Railway. When this great work has made commerce with the nations of Europe a necessity to the manufacturing interests of England, we will be chary about provoking a European war; or of raising a barrier between our trade and our customers, by quarrelling with France. When France sees her railway system become the nucleus of the commerce and travel of Europe; when her neighbours east and west pay transit tolls on traffic passing over her lines, and she is thriving by their prosperity as well as by her own industry—if such wisdom continue to guide her councils as happily directs them now, her soldiers will be employed as conservators of peace, not myrmidons of war. When England and France, mutually interested in the peace of Europe, have their glorious alliance strengthened by the iron bands of the Channel Railway, other nations will pause before disturbing that peace, and offending powers which, thus united, might insure the peace of the world.

All good and great men should encourage the Channel Railway. If improvements in locomotion are held to be blessings; if railways and steamboats have promoted the interests of commerce and manufactures, and opened new sources of comfort and happiness to mankind; then should the Channel Railway be encouraged.

In connection with its commercial and civilizing influence on the nations, let us glance once more at the item of expenditure. England and France have, within the last hundred years, expended more in wars than would build a hundred works like the Channel Railway; and who can tell what its influence might be in averting future quarrels? If it were the means of shortening, by only one month, such wars as these nations are now prepared to wage, that alone would amply pay for its construction. Wars are sometimes undertaken to maintain a nation's rights; they are more frequently waged to vindicate some nice, but often worthless point of national honour, when they become duelling on a grand scale; the bloodiest of European wars have been fought to maintain the balance of power: in all of these, efficiency to destroy has been the first consideration, expenditure the last. But when works of this kind claim attention, expenditure often receives undue prominence; though a tithe of the millions spent in war, if thus appropriated, would give a larger return in all that tends to make a people great, to vindicate their honour, and strengthen their voice among the nations.

A P P E N D I X.

MR. COBDEN AND THE CHANNEL RAILWAY.

THE state of trade, in consequence of the American war, and the financial circumstances referred to in the following letter, happily no longer exist :—

Midhurst, 8th Nov., 1861.

“DEAR SIR,—I do not consider Mr. Fairbairn’s report unfavourable, but the contrary. He does not say your scheme is impracticable; and, as regards the inopportuneness of the present moment for carrying it out, I think he is quite right; for, if there were no other impediments, the state of trade, and the financial condition of the French Government, are quite sufficient reasons why the project should not be taken up *now*.

“If not impracticable in an engineering sense, I have no doubt it will be executed some day. Perhaps the fact of the tubular principle having been used for *bridges* where they were really not called for, and where, consequently, they afforded a grand triumph of engineering skill, at a ruinous cost to the railway companies, will be felt as an obstacle in a financial point of view, in the attempt to form a company to carry out your project. I return Mr. Fairbairn’s letter,

“And remain, truly yours,

“James Chalmers, Esq.”

“R. COBDEN.

Mr. Cobden’s kindly efforts in favour of the writer and his project were never relaxed; and the correspondence, begun in 1861, terminated only with his death. In a letter, dated July 29th, 1862, he said: “I admire your courage and constancy, but sometimes almost tremble for the sacrifice you are incurring for an idea.” With reference to the Chalmers Target, he wrote, December 13th, 1862: “I must confess to a little dislike for all such warlike contrivances;” and, in answer to a letter pointing out the purely defensive nature of the contrivance in question, he wrote the following note :—

Midhurst, 17th Dec., 1862.

"DEAR SIR—I did not speak of your warlike contrivances reproachfully; for I quite agree with you, that these scientific armaments are calculated more to favour those who are on the defensive than those who are aggressors. This is, I think, a very salutary tendency of the progress of mechanical discoveries.

"I remain, truly yours,

"James Chalmers, Esq."

"R. COBDEN.

In July, 1863, referring to the successful trial of the Chalmers Target, he wrote, "If it were in my power, which it is not, I should be glad to be your backer in the ingenious and successful struggle you are waging against red-tape and routine." Again, in March, 1864. "I have seen with satisfaction your successful achievement with your iron target, though I fear it has brought you more praise than pudding." Mr. Cobden's last letter is dated Midhurst, 28th February, 1865, about a month before his death; and it expresses the kindly interest which he says: "I shall always feel in those matters to which you have called my attention."

"LE TESTAMENT DE COBDEN."

TO THE EDITOR OF THE "STAR."

SIR,—I was not aware, till I saw your Paris correspondent's letter, commenting on an article in *La Patrie*, with the above title, that Mr. Cobden referred to the "Anglo-French Submarine Tunnel" on his death-bed. Whether *La Patrie* be correctly informed or not, as to the great Free-trader's dying advice; it is well known that he had the subject of "better facilities of communication with France" very much at heart. When the Channel Railway project of Mr. Chalmers was first brought before the public, Mr. Cobden gave it his hearty support, and introduced it to M. Fould and M. Chevalier in France, and to such gentlemen in England as he thought would be likely to promote the enterprise. The opposition of Lord Palmerston, who then held that it was undesirable to increase our facilities of intercourse with France, delayed the consideration of the project for a time. But Mr. Cobden continued to regard the efforts of the inventor with a lively interest, and rejoiced in the triumph of the Chalmers Target as a promise of success for the more congenial and nobler undertaking. One of the very last letters written by Mr. Cobden was a note of friendly encouragement to the projector of the Channel Railway.—I am, sir, your obedient servant,

London, June 25, 1866.

A. M. T.

TO RAILWAY SHAREHOLDERS IN ENGLAND AND FRANCE.

GENTLEMEN,—A few years ago, the great interests you now represent had no existence. The world's history would be searched in vain to find a parallel to the material progress of the past thirty years—a progress towards which railways have largely contributed. During this period, the once humble carrier has become the representative of a capital equalling the wealth of kingdoms—a power, second only to the great sovereignties of the world. These results are simply the fruit of enterprise directed into new channels; and the development of this immense wealth and power, with their concomitant advantages, is yet in its infancy: but the bold course that has hitherto characterized railway enterprise must not be departed from, if we desire such prosperity as distinguished the past.

The chief hindrances to the expansion of our railway systems have been physical impediments occasioning breaks in lines. Some of these, from time to time, have been removed by expenditures greatly disproportioned to the subsequent traffic; and, consequently, have been burdensome and unprofitable to the companies concerned; but, in cases where great works were necessary to connect important points, the advantages derived from their completion have always been such as would compare favourably with the expenditure.

• One of the greatest impediments to the full development of the English and Continental railway systems is the break in the connection occasioned by the Channel. To this point I would respectfully direct your attention; not again to discuss the magnitude of the obstruction, nor the practicability of surmounting it, but to remind you once more of the mighty interests affected by it, and of the results which its removal would have on hundreds of millions of railway property. It is universally admitted, that the value of this property in England and France would be greatly improved by a Channel Railway, which would connect the lines of the two countries; and it is generally admitted that such a work is perfectly practicable, though there is some difference of opinion as to the best method of accomplishing it; but, whatever diversity of opinion may exist on this and other points, there seems to be none regarding its commercial success, when completed; provided the cost does not materially exceed the generally received estimate. From an expenditure of £12,000,000, a nett revenue of £1,200,000 is anticipated; and the collateral advantages to existing railway companies and the

public, are expected to surpass in value the direct revenues of the undertaking itself.

In thus addressing you, my object is not to multiply arguments in favour of the practicability of my own project, but to suggest the desirability of a careful inquiry into the fundamental question of a railway connection. The questions for consideration might be:—

First. Would large steamers, constructed to carry a train across, meet the exigencies of the case? And does the experience acquired at Edinburgh, Dundee, Montreal, and Detroit, warrant the expenditure?

Second. Can a tunnel be driven under the bottom of the sea? And, are the histories of the Thames and Mont Cenis tunnels sufficiently encouraging, as regards the probable cost, and the time required for such an undertaking?

Third. Is it practicable to effect this connection by means of a tubular railway on the bottom of the Channel? If this idea should be considered the most feasible, several tubular projects might be examined, and if necessary experimented on. As to my own, a simple experiment on the method proposed for joining the tubes would decide its practicability. Or, a model of the Channel Railway, which would not cost over £6,000, could, with the consent of the French Government, be placed in the Lake of the Bois de Boulogne. Such model, if decided on by the beginning of March, could be ready by the middle of April, when it could be submerged, and connected from shore to shore in three days; and, if only one in ten of the millions that will visit Paris next summer would pass through it at half a franc each, it would not only pay for its construction, but leave a profit of one hundred per cent.

As a Railway Congress in Paris during the ensuing summer could discuss this and other interesting questions with much advantage, I respectfully commend the subject to the attention of railway shareholders; and suggest that a committee, composed of gentlemen connected with the principal lines of both countries, be appointed to inquire into the feasibility of establishing a permanent railway connection at the narrowest part of the Channel, with a view to profit by the many favourable circumstances which the present time offers for introducing and completing so important an undertaking.

I am, Gentlemen,

Your obedient servant,

JAMES CHALMERS.

HAVERSTOCK HILL,
London, January, 1867.

FRANCE

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1 IN 150

FATHOMS = 6 FT!







